6-10-70

PATENT SPECIFICATION

1,194,358

DRAWINGS ATTACHED.

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COMPLETE SPECIFICATION.

Fluid Flow Control Valve.

I, DANA CHRISTOPHER MEARS, of 18 Hastoe Grange, Headley Way, Headington, Oxford, a citizen of the United States of America, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a magnetically operated rotary action fluid flow control valve particularly but not exclusively intended to be of small size for the regulation of fluid flow in the human body or the use in industry.

A magnetically operated fluid flow control valve according to this invention comprises a magnetically operated fluid flow control valve comprising a casing with an inside seating surface, and a disc rotatably confined within the casing opposite the seating surface and having a fluid flow port which is alignable with a fluid flow port in the casing which opens into the seating surface, the casing and the disc each having an associated permanent bar magnet and the disc being rotatable by means of a magnetic field manipulated externally of the casing from the position which it automatically assumes relative to the casing as a result of the normal interaction of the bar magnets when the magnetic field is absent.

Preferably the disc can be displaced under the effect of fluid pressure or by an external magnetic field away from the fixed element by overcoming the attraction between the permanent magnets. The sealing surfaces do not then erode one another when the disc is turned. In such a valve for use in the human body, for instance for the purpose of urinary bladder control, the two flow ports are semi-circles with radii of the same magnitude as the diameter of an inlet and an outlet of the valve to permit passage of sediment such as renal calculi, with a diameter up to approximately that of the inlet tube. Instruments, such as cystoscopes and fibre glass viewing tubes can be passed through the valve to study the entire length of the inlet tube, the inner surface of the valve and the outlet tube, as well as parameters of the fluid.

In such a valve which is designed to be normally closed the magnetic force of attraction between the valve elements is much greater than the hydrostatic force of the fluid on the inlet side of the movable valve element. If this hydrostatic force should increase beyond some predetermined magnitude it moves the disc away from the sealing surface of the casing so that the valve leaks into the outlet part of the shell and prevents rupture of the inlet tube.

Two particular and at present preferred forms of valve according to the invention, one of which is intended for regulation of flow of urine in the human body, and the other of which is intended for industrial use, are illustrated by way of example in the accompanying drawings, in which:—

Figures 1, 2 and 3 are respectively plan, side elevation and inverted plan views of the valve;

Figure 4 is a section on line IV—IV of Figure 2;

Figure 5 is a section on line V—V of Figure 1;

Figure 6 is a section on line VI—VI of Figure 2;

Figures 7 and 8 are schematic side and top views respectively which show another form of valve in open position; and

Figures 9 and 10 are schematic side and top views respectively corresponding to Figures 7 and 8 and showing the same valve in closed position.

Referring first to Figures 1 to 6, the valve has a casing which comprises an annular shell 1 which tapers internally and externally at one end, and a co-axial end element or disc 2 fixed within the non-tapered end. The

casing shell confines a co-axial disc 3 which is turnable within the tapered end of the shell 1. The fixed disc 2 has a substantially semi-circular inlet port 2*a* at one side of a diametrically incorporated cylindrical permanent bar magnet 4 whilst the turnable disc 3 has a substantially semi-circular outlet port 3*a* situated to one side of a cylindrical permanent bar magnet 5.

The annular shell 1 and the discs 2 and 3 are machined or moulded from polytetrafluorethylene although they can be made from polypropylene, polycarbonate, high density polyethylene, ceramics, pure titanium, titanium alloys and cobalt-chromium surgical alloys. The exterior of the shell is covered with Dacron (Registered Trade Mark) velour which allows tissue encapsulation. Tissue encapsulation may be assisted by extension of the Dacron covering beyond the valve and into the urethrea. The extensions narrow to a diameter of about 5 mm. In the favoured design the shell body has an outside diameter of 1.6 cm. although it might range from 0.5—2.0 cm. The shell is 6 mm. high in the favoured design although it might be 3.0—10 mm. high. The shell has two radial projections 1*a* from its rim that limit turning of the disc 3 to 180 (i.e. from full open to closed) by contact with a lug 6 on the disc 3. While one half of the lower end of the shell 1 could be enclosed, as an alternative method of limiting rotation of the disc 3, the shell 1 and disc 3 would then be more likely to silt-up with the precipitates formed from the super-saturated urine. Figures 2 and 5 show how the fixed disc 2 is held in the shell by engaging wedge surfaces. In addition radial pegs (not shown) can be inserted to fasten this fixed disc to the shell. When the shell is made from other materials the disc 2 may be screwed, welded or glued to the shell or it may be integral with it. The inner surface of the shell is here shown as having a ledge to locate the end surface of the disc 2. The narrowing inside end surface of the shell body forms a bearing surface during movement of the movable disc 3. The shell 1 can be made more rigid by reinforcement with titanium alloy wires.

The turnable disc 3 has a tapered edge which matches the taper of the shell (Figure 5). Instead of a single substantially semi-circular outlet port it may have one or more round or otherwise shaped holes. Each of the permanent magnets 4 and 5 is made of a ferrous alloy such as that known under the Registered Trade Mark Alcomax or of a cobalt-platinum alloy and they are sealed in position with polytetrafluoroethylene plugs 4*a* and 5*a* respectively. Each permanent magnet has a diameter of about 1 mm. and a length of about 1 cm., although the size and shape depend on the magnetic alloy and the size and function of the valve.

The disc 3 has a diameter of 1.3 cm. It could alternatively have a diameter in the range 0.5—1.8 cm. (Figure 3). Its sealing and bearing surfaces are highly polished. The disc 2 is similarly dimensioned.

An external controlling magnet for a valve as above described is a U-shaped permanent magnet of Alcomax of approximately 7×6×2 cm. with a gap of about 2 cm. between the poles.

For industrial application, the general configuration of the valve is similar to that described above for the control of urine flow although the valve may be much larger in size.

One such valve is shown schematically in Figures 7 to 10 inclusive of the accompanying drawings, from which it can be seen that a shell 30 has an inlet tube 31 and outlet tube 32. In this embodiment the fixed valve element with which a movable valve element in the form of a disc 33 engages, is integral with the shell 30. Bar magnets 36, 37 respectively are dispersed within the shell 30 and within the disc 33.

The valve may be constructed of plastics, metallic alloys, ceramics, glass, rubber or composites. The disc 33 may be proximal or distal to the sealing surface of the shell 30 with respect to the direction of fluid flow. The port 33*a* in the movable disc may be of the same size and shape as that of the inlet and outlet so that laminar flow through the valve may be achieved. The sealing and bearing surfaces of the movable disc and shell may be flat or curved and the controlling magnet may be an electro-magnet as an alternative to a permanent magnet. When a curved solenoid is used as an alternative to an embedded permanent magnet the centre of the movable disc can be more readily modified, as for instance to provide several ports.

The mode of operation of the valve according to the invention should be apparent from Figures 7 to 9 which show a U-shaped controlling magnet 35 located above the movable disc for the industrial model, and wherein all magnet poles are marked N (North) or S (South) as appropriate.

For the operation of the valve for the regulation of urine flow, the controlling magnet is located below the valve. Initially the controlling magnet 35 is moved into a position where its poles are about 8 cm. directly below the poles of the valve magnets with the North and South poles aligned. The controlling magnet is rotated in the same plane as the movable disc 33 until fluid flow is maximal (indicative that the movable disc has rotated 180° to the full open position). The controlling

magnet is held in the position of maximum fluid flow until flow ceases.

When the controlling magnet is withdrawn, the movable disc rotates automatically to the closed position. If a patient is unable to operate his valve, the valve will automatically leak when the pressure in the urethra proximal to the valve is raised above the force of attraction between the movable and stationary discs. If surgical exploration of the urogenital tract or of the valve is required, instruments can be passed through the open valve.

Operation of industrial models of the valve is approximately the same as operation of valves for use in the body. Where minimum abrasion of the seating surfaces is desirable, initial manipulation of the controlling magnet draws the movable disc away from the seating surface of the fixed disc or casing. The controlling magnet is then manipulated to rotate the movable disc. Where only full open and closed positions of the valve are required, the controlling electro-magnet can be fixed and its polarity switched to move the movable disc.

Alternatively the movable disc can be controlled synchronously with equipment in other parts of a system, e.g. a complex system of chemical plant by, for example, a rotating magnetic field. Two or more valves can be mounted in parallel in the same housing. The valve may have two or more inlets and outlets. Also two or more movable discs can be placed concentrically in the same shell or casing. If the movable discs contain embedded magnets of dissimilar strengths changes in the external field can selectively rotate one or more movable discs. If, for example, a valve has one central inlet, six outlets equidistant from the centre of the shell, and a movable disc with a diagonal port of the same diameter as the inlet and outlets and spanning from the inlet to any outlet, rotation of the movable disc will permit flow from the inlet to any outlet or no flow if the movable disc is rotated so that its port is not opposed to an outlet port. If, for example, a body with six inlets and six opposing outlets contains one movable disc with a vertical port of the same diameter as the inlets and outlets, rotation of the movable disc by an external field permits flow through any particular inlet and the opposing outlet. If a similar valve contains two movable discs of the same size but with embedded magnets of different strengths. each with a diagonal port of the same diameter as the inlets and outlets and spanning from the inlet port or outlet port to the centre of the movable disc, then rotation of one or both movable discs will permit flow through any inlet and outlet.

It should be appreciated that because a valve according to the invention can be operated by remote control no stem need be attached to the movable part; and there is no need for a complex bearing system. Little or no maintenance is required over long periods of service and such a valve could be expected to function in the humane body for the duration of a life time of an adult without any servicing.

Any leakage of the sealing surface is only internal leakage (i.e. from the inlet to the outlet) and not external. Hence the valve is useful for regulation of flow of obnoxious fluids. The area of the port can be large compared with the area of the entire valve. Hence where space is restricted a larger valve bore for a given external size is possible compared with most other remotely controlled valves.

The valve leaks automatically from the inlet into the outlet if the pressure in the inlet rises above some predetermined level. This mode of fail-safe requires no additional power supply and no connections with the movable part. This feature can be removed by using the valve in the inverted position. Movement of the movable element or disc provides a self-cleaning action which may remove silt from most of the internal surfaces of the valve.

When the movable disc is placed adjacent the seating surface of a fixed disc or casing, the bearing surfaces are separated by fluid during valve operation so that abrasion of the bearing surfaces is negligible. An extremely slow rate of abrasion of the sealing surfaces can be achieved if the controlling magnet first separates the movable disc from the seating surface and then rotates the disc. Laminar flow can be achieved through the fully open valve. Instruments can be passed through the open valve to examine the interior of the inlet, outlet, and of the valve. Similarly, properties of the fluid within the valve or through the valve can be measured during fluid flow.

When the valve is constructed of polytetrafluoroethylene only this exceptionally inert material is in contact with the working fluid. Hence the valve is very resistant to dissolution as well as erosion. Very low torque is required to operate the valve. Hence the mobility of patients with valves is not restricted by the size of the controlling magnet. After initial disc movement, the valve returns automatically to a pre-selected open or closed position.

WHAT I CLAIM IS:—

1. A magnetically operated fluid flow control valve comprising a casing with an inside seating surface, and a disc rotatably confined within the casing opposite the seating surface and having a fluid flow port which is alignable with a fluid flow port in the casing which opens into the seating sur-

face, the casing and the disc each having an associated permanent bar magnet and the disc being rotatable by means of a magnetic field manipulated externally of the casing from the position which it automatically assumes relative to the casing as a result of the normal interaction of the bar magnets when the magnetic field is absent.

2. A magnetically operated fluid flow control valve as claimed in claim 1 in which said disc is also axially movable out of engagement with the seating surface under the effect of fluid pressure or of the externally manipulated magnetic field.

3. A magnetically operated fluid flow control valve as claimed in claim 1 and having a plurality of said rotatable discs each having at least one fluid flow port and an associated permanent bar magnet as aforesaid.

4. A magnetically operated fluid flow control valve as claimed in any of claims 1. 2 or 3 wherein said permanent bar magnets are diametrically arranged.

5. A magnetically operated fluid flow control valve as claimed in any of claims 1 to 4 wherein said casing comprises an annular shell with a disc fixed therein and formed with a fluid flow port.

6. A magnetically operated fluid flow control valve as claimed in claim 1 and 5 in which the shell tapers inwardly at the end remote from the fixed disc and thereby confines the movable disc which has a tapered surface complementary to an inside tapered surface of the shell.

7. A magnetically operated fluid flow control valve as claimed in any of claims 1 to 6 in which a single fluid flow port in a rotary disc is of substantially semi-circular shape.

8. A magnetically operated fluid flow control valve as claimed in any of claims 1 to 3 wherein the seating surface is part spherical and said disc has a complementary part spherical surface.

9. A magnetically operated fluid flow control valve as claimed in claim 3 in which the permanent bar magnets in the discs are of different strengths.

10. A magnetically operated fluid flow control valve as claimed in any of claims 1 to 9 in which a said rotary disc or discs is controllable synchronously with equipment in other parts of a system of which the flow control valve is a component part.

11. A magnetically operated fluid flow control valve substantially as hereinbefore described with reference to and as shown in Figures 1 to 6 or Figures 7 to 10 of the accompanying drawings.

MARKS & CLERK,
Chartered Patent Agents,
Agents for the Applicants.

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251/65

1194358 COMPLETE SPECIFICATION

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Sheet 1

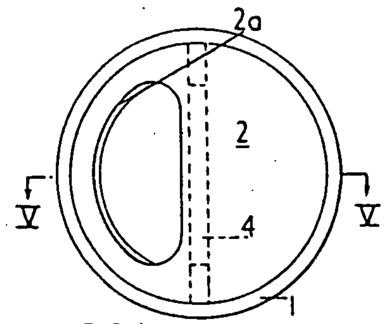

FIG. 1

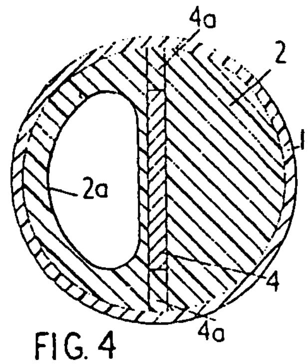

FIG. 4

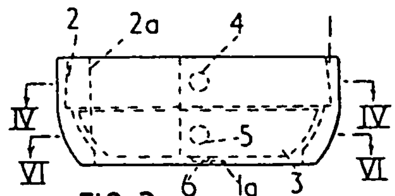

FIG. 2

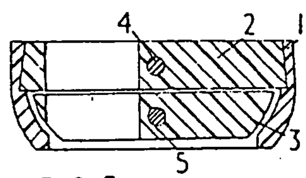

FIG. 5

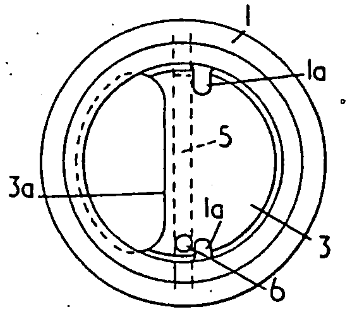

FIG. 3

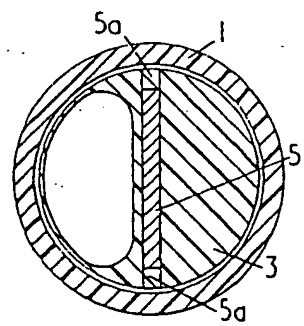

FIG. 6

1194358 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

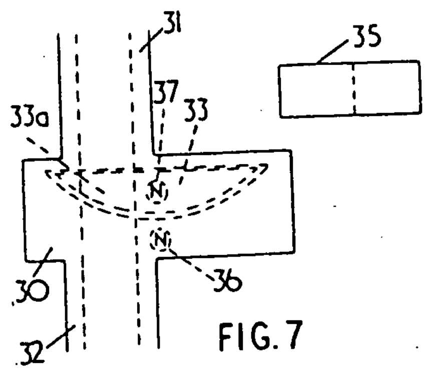

FIG. 7

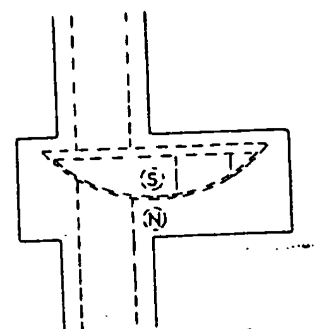

FIG. 9

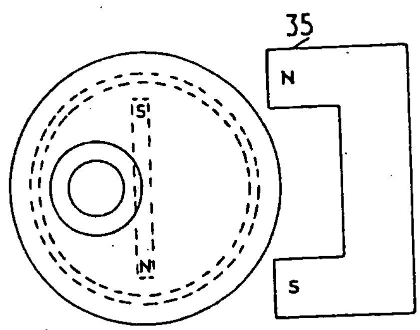

FIG. 8

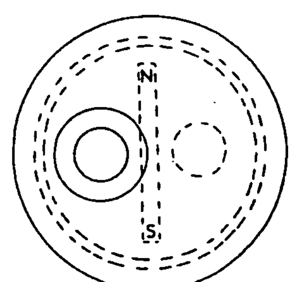

FIG. 10